2004 Return to *Titanic* Expedition

What's Eating *Titanic*?

Focus
Biodeterioration processes

Grade Level
9 - 12 (Physical Science/Biological Science)

Focus Question
What processes are responsible for rapid deterioration of the wreck of *Titanic*?

Learning Objectives
Students will be able to describe three processes that contribute to the deterioration of the wreck of *Titanic*.

Students will be able to define and describe rusticles, and explain their contribution to biodeterioration of *Titanic*.

Students will be able to explain how processes that oxidize iron in *Titanic's* hull differ from iron oxidation processes in shallow water.

Materials
❒ Library and/or Internet access

Audio/Visual Materials
❒ Overhead projector and transparencies

Teaching Time
One 45-minute class period, plus time for student research

Seating Arrangement
Classroom-style or groups of 3 - 4 students

Maximum Number of Students
30

Key Words
Titanic
Rusticle
Biodeterioration

Background Information
At 11:40 pm on April 14, 1912, RMS *Titanic* struck an iceberg off the coast of Newfoundland. Two hours and 40 minutes later, the great liner sank 3,900 meters to the bottom of the North Atlantic Ocean. Thought to be unsinkable, *Titanic* had not survived her maiden voyage. Neither did 1,522 passengers and crew members who also perished on that cold April morning.

In 1985, *Titanic* was seen again by explorers from the Woods Hole Oceanographic Institution and the Institut Français de Recherches pour L'Exploitation des Mers. Using the remotely operated vehicle (ROV) Argo, the explorers made dramatic video recordings showing changes brought about by 73 years in the deep ocean. Since the initial discovery in 1985, *Titanic* has been visited by numerous other expeditions, many of which have taken away considerably more than video images. At the end of 2002, an estimated 6,000 artifacts had been removed from the *Titanic* wreck site. These activities have stirred controversy, since the *Titanic* shipwreck is unquestionably a gravesite as well. This fact is underscored by video images of paired shoes (for example, at http://members.aol.com/tinsleyfam/titanicpresent.html lying on the ocean floor in positions that suggest the shoes have not moved since the person wearing them landed on the bottom. Visit http://www.imacdigest.com/archrepo.html for a list of artifacts removed from the *Titanic* site in 2000.

In addition to damage caused by recent human activities, the remains of *Titanic* have been subjected to more than 90 years of natural degradation processes as well. One of these processes, known as "galvanic exchange," results from the presence of different metals in contact with seawater. Metals can be classified into an "Electromotive Series" according to the strength with which they "hold on" to their electrons. Metals higher in the Series tend to draw electrons away from metals that are lower in the Series. When two metals with different electromotive strengths are connected by an electrolyte (such as salt water), electrons will flow from the metal lower in the electromotive series, causing this metal to form oxides or other compounds in a process we know as corrosion (this is also the process through which batteries produce an electric current). Besides the iron in its hull, *Titanic* contains many other metals such as bronze and brass that are higher in the Electromotive Series than iron. As a result, the steel in *Titanic's* hull is degraded as iron is replaced by other compounds formed through galvanic exchange.

It has been suggested that galvanic exchange was the real reason *Titanic* sank in the first place. Since the ship was held together by 3 million rivets made with wrought iron (which is a different material than the hull plates), galvanic exchange could have taken place between the dissimilar metals of the hull and rivets causing the rivets to weaken. In fact, *Titanic* sat in seawater for a year after her hull was launched while the interior was furnished. One of the last photos taken before the ship's maiden voyage shows a pattern that may suggest the rivets were rusting faster than the hull plates. When *Titanic* collided with the iceberg, the weakened rivets could have popped (which would account for a clinking sound reported by some survivors). An opening just an inch wide between the hull plates would have been enought to sink the ship…and video images of the wreckage show a narrow opening in the unburied part of the bow, as well as preferential corrosion of the rivets in some areas. For more information on this theory, visit http://www.corrosion-doctors.org/Landmarks/titan-sinking.htm.

The mission of the 2004 Return to *Titanic* Expedition is to assess changes that have occurred at the RMS *Titanic* wreck site since 1985, and to investigate natural degradation processes as well as changes caused by human activity.

In this lesson, students will investigate another natural degradation process that may account for much of the deterioration that appears to be taking place on the remains of the *Titanic*.

Learning Procedure

1. Download a copy of the press release, "Return to *Titanic* Mission to Document Wreck's Destruction" from http://news.nationalgeographic.com/news/2004/04/0423_040423_titanicscience.html. Make an overhead transparency of the title and first paragraph.

   Visit http://oceanexplorer.noaa.gov and www.returntotitanic.com for up-to-date information on the 2003 and 2004 Return to *Titanic* Expeditions.

2. Briefly review the history of *Titanic*, its sinking, discovery of the shipwreck in 1985, and human activities at the site following this discovery. Show students the overhead transparency, and ask what processes might be responsible for the alarming and possibly increasing rate of deterioration. Students should recognize that both natural and human-induced processes may be involved, and may distinguish between galvanic action and "rusting." If you have serious *Titanic* fans in your class, they may also know about rusticles. Tell students that their assignment is to investigate biodeterioration of *Titanic*. If rusticles have not been mentioned, let them discover the associated process through their own research. Have each student or student group prepare a

written report on biodeterioration which should include answers to the following questions:

- How is "rusting" on *Titanic* different from rusting on shipwrecks in shallower waters?
- What processes may slow rusting of shipwrecks in shallower waters, and why aren't these processes happening on *Titanic*?
- About how rapidly does biodeterioration remove iron from *Titanic's* hull?
- If we assume that *Titanic's* hull contained 46,000 tons of iron and is covered with 380 tons of biodeteriorating organisms, how long would it take for the hull to be completely dissolved by biodeterioration processes alone?

3. Lead a discussion of students' research. The following points should emerge in this discussion:
   - The most conspicuous biodegradation process affecting *Titanic* is caused by complex communities of bacteria and fungi that produce structures called "rusticles."
   - Oxidation of iron in *Titanic's* hull results from biological activity of rusticle communities under anaerobic conditions, and is a different process from rusting in shallow waters resulting from oxidation of iron by dissolved oxygen.
   - Rusticles superficially resemble icicles or stalactites, and are built up in ring structures that are highly porous with channels and reservoirs that allow water to flow through.
   - Up to 35% of rusticles' mass consists of iron compounds (iron oxides, iron carbonates, and iron hydroxides). The remainder is biomass of bacteria and fungi.
   - Rusticles grown in laboratories have been found to continuously release a red, powder-like material as well as a yellowish slime. The iron content of these materials is 20 ± 5% and 8 ± 3% respectively.
   - Rusticles release between 0.02 and 0.03% of their biomass per day. So the amount of iron released by a rusticle biomass of 1,000 tons would be between 0.076 and 0.114 tons per day.:

     0.0002 • 1,000 tons = 0.2 tons per day

     0.0003 • 1,000 tons = 0.3 tons per day

   So, to consume 40,000 tons of iron this biomass of rusticles would require between

   (46,000 tons) ÷ (0.2 tons/day) = 230,000 days = 630 years

   (46,000 tons) ÷ (0.3 tons/day) = 153,333 days = 420 years

   Estimates of the time required to completely dissolve *Titanic's* bow section range from 280 to 420 years. Students should realize that these estimates are based upon rates observed under laboratory conditions, and may be considerably different from actual rates at the *Titanic* site. Experiments currently underway at the site are designed to give better estimates of the actual rates.

   Students should realize that the superstructure of *Titanic* will collapse long before the hull is completely dissolved, and that other processes (such as galvanic exchange and human-caused damage) may combine with biodeterioration to destroy the remains of *Titanic's* interior in much less time than these calculations suggest.

The BRIDGE Connection

www.vims.edu/bridge/ – In the Navigation toolbar, click on "Ocean Science Topics," then "Human Activities," then Archeology. Also, search keyword "*Titanic*" in the "Search" box for more locations on the BRIDGE site dealing with *Titanic* topics.

The "Me" Connection

Have students write a brief essay discussing whether or not artifacts should be removed from *Titanic*, and why people feel strongly about a wreck that happened nearly 100 years ago.

Connections to Other Subjects

English/Language Arts, Earth Science, Social Studies, Life Science

Evaluation

Written reports prepared by students or student groups in Step 2 and class discussions provide opportunities for evaluation.

Extensions

Have students visit http://oceanexplorer.noaa.gov and www.returntotitanic.com to find out more about the 2004 Return to *Titanic* Expedition, and to learn about opportunities for real-time interaction with scientists on current Ocean Exploration expeditions.

Have students investigate initiatives to protect the wreck of *Titanic*, and discuss the merits of salvage vs. protection.

Have students investigate one or more persons who were aboard *Titanic* when it sank, and prepare a report on their activities on April 14 and 15, 1912.

Resources

http://www.corrosion-doctors.org/ – A web site about corrosion causes and solutions, with modules designed for training in corrosion science and engineering

http://www.encyclopedia-titanica.org/index.php — Encyclopedia Titanica website with biographies, research articles and ongoing discussions about the *Titanic*

http://score.rims.k12.ca.us/activity/bubbles/ – Marine archaeology activity guide based on investigations of the wreck of a Spanish galleon; from the Schools of California Online Resources for Education web site

http://www.titanic1.org/ – *Titanic* Historical Society

http://www.titanicinquiry.org/ – *Titanic* Inquiry Project

http://www.skarr.com/titanic/ – The *Titanic* Information Site

http://ourworld.compuserve.com/homepages/Carpathia/ – *Titanic* Tidbits

http://www.sciencedrive.com/mitchk/titanic.htm#titanic – The Unsinkable RMS *Titanic*

http://members.tripod.com/~hoko/index-4.html – *Titanic* Links

http://www.titanicscience.com/TSci-ActivityGuideFinal.pdf – Maryland Science Center's *Titanic* Science Teacher Activity Guide

http://www.jasonproject.org/jason_project/jason_project.htm – web site for the multidisciplinary JASON project designed to expose students to leading scientists who work with them to examine the Earth's biological and geological development

Archbold, R. and D. McCauley. 1997. *Last Dinner on the* Titanic. Madison Press. Toronto.

Ballard, R. D. with R. Archbold. 1995. *The Discovery of the* Titanic. Warner Books. New York.

Lord, W. 1986. *The Night Lives On*. William Morrow and Company, Inc. New York.

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Chemical reactions
- Motions and forces
- Conservation of energy and increase in disorder

Content Standard C: Life Science
- Interdependence of organisms
- Matter, energy, and organization in living systems

Content Standard E: Science and Technology
- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Natural and human-induced hazards

For More Information
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